The Prospective Value of Space Solar Power as Renewable Energy: Implications for the Biosphere, Energy Security, and Overall Sustainable Economic Growth

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RESOURCES

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Approach

- **Theoretical Framework**

Measure of expected societal benefits from innovation in electric power generation

External effects: biosphere and energy security/reliability

Use of index, counterfactual

Adoption rate

Uncertainty (data, forecasts)

Discount rate

- **Our Application**

Electricity generation technologies:

-- Space solar power

-- Terr'l renewable (PV, solar thermal, biomass, wind, geothermal)

--Fossil (Combined cycle gas turbine -- conventional and advanced designs)

Geographic/market regions

Weibull ("fast," "slow") for additions to capacity

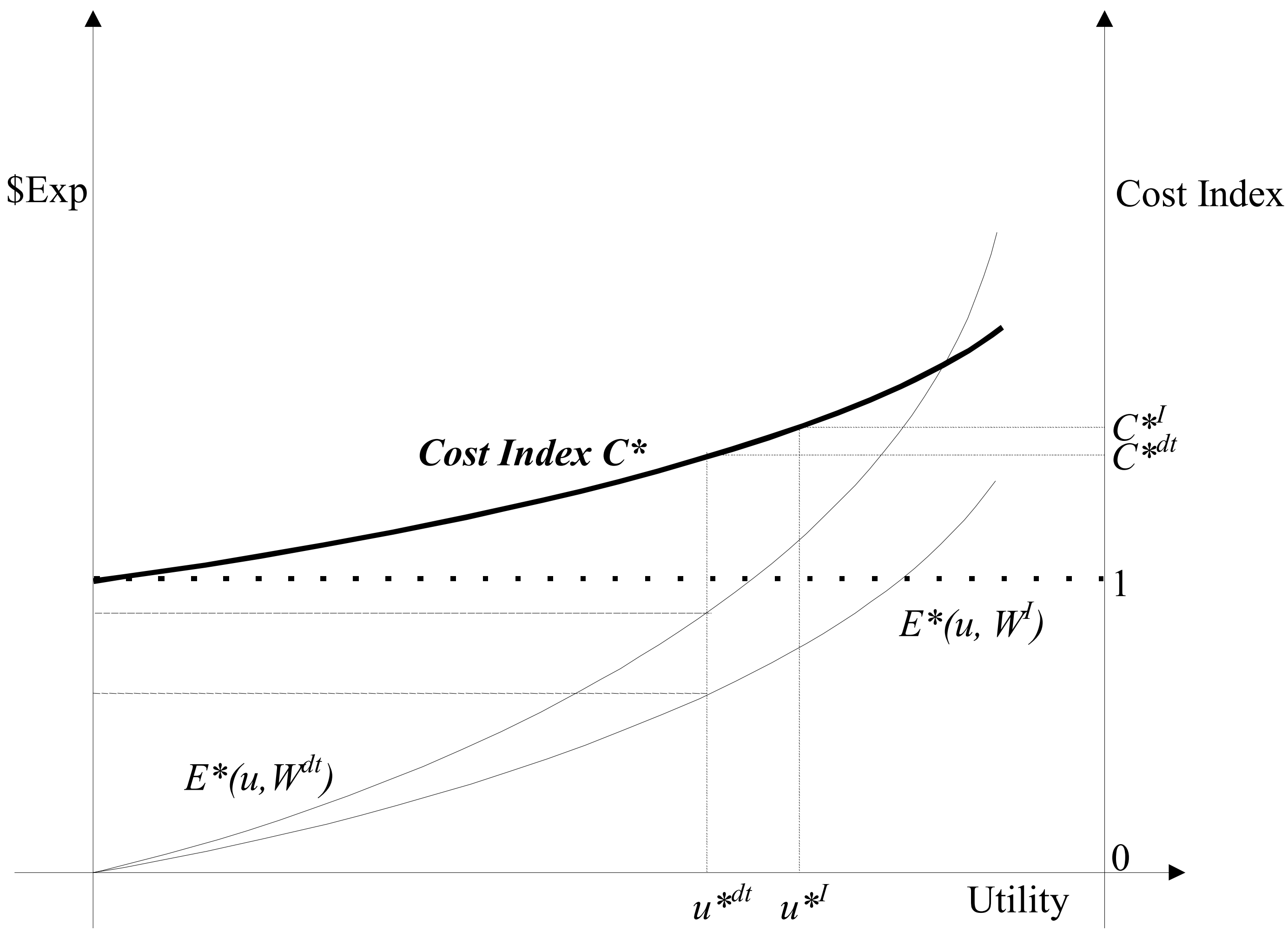
Time period: 2000-2020

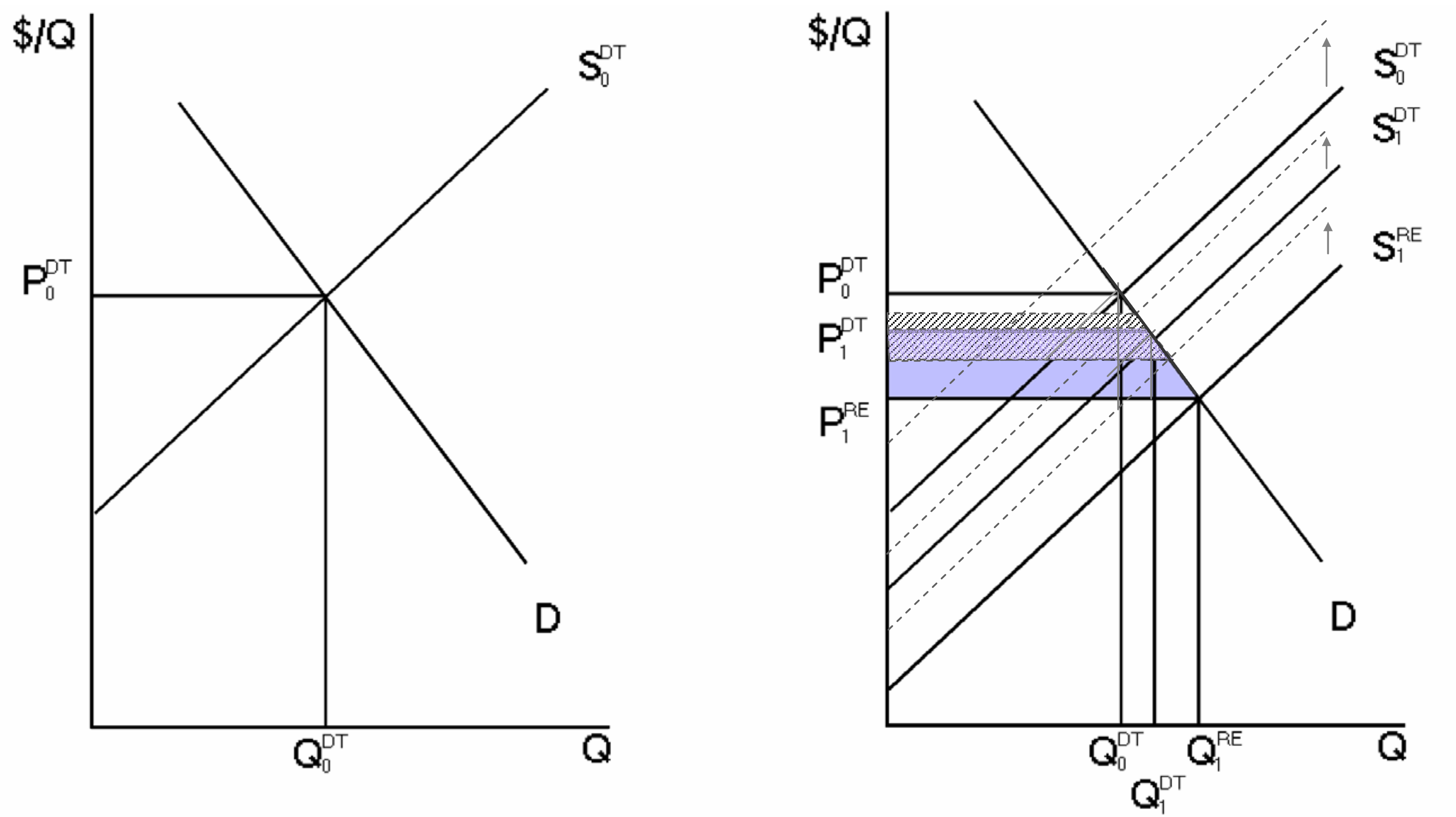
Using the index to estimate the present value of consumer benefits

Interpretation of the index: "how much better off are we (that is, society in general) as a result of investment in new technology, taking into account the alternative (conventional technology) and differences in the external (or social) benefits* and costs between the new and conventional technologies?"

* Biosphere and energy security/reliability effects

Relationship between expenditures, cost index





Derived demand for new energy technologies: illustration of surplus change with external costs

Derivation of estimating relationships

$$C^{*dt} = \frac{E^* (u^{dt}, P^{dt}, W^{dt})}{E^* (u^{dt}, P^{I}, W^{I})}$$

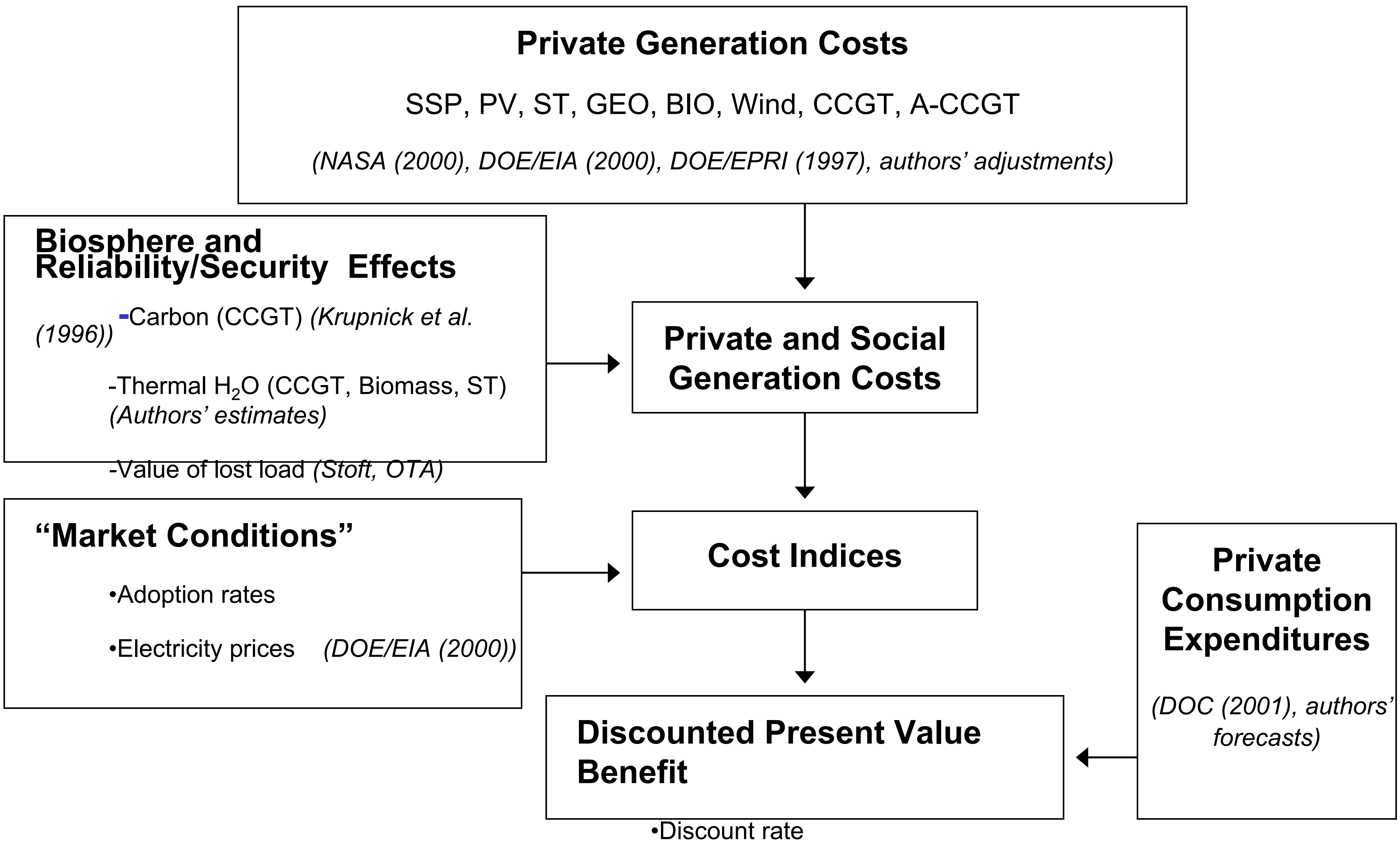
$$\text{and } C^{*I} = \frac{E^* (u^{I}, P^{dt}, W^{dt})}{E^* (u^{I}, P^{I}, W^{I})} \qquad (1)$$

$$½\, ln\, (C^{*dt}\ x\ C^{*I}) = ½\, (s^{dt} + s^{I})\, ln\, (W^{dt} / W^{I}) \quad (2)$$

(Bresnahan, AER 1986)

$$W^{I} = \rho\, W^{I} + (1 - \rho)\, W^{dt} \qquad (3)$$

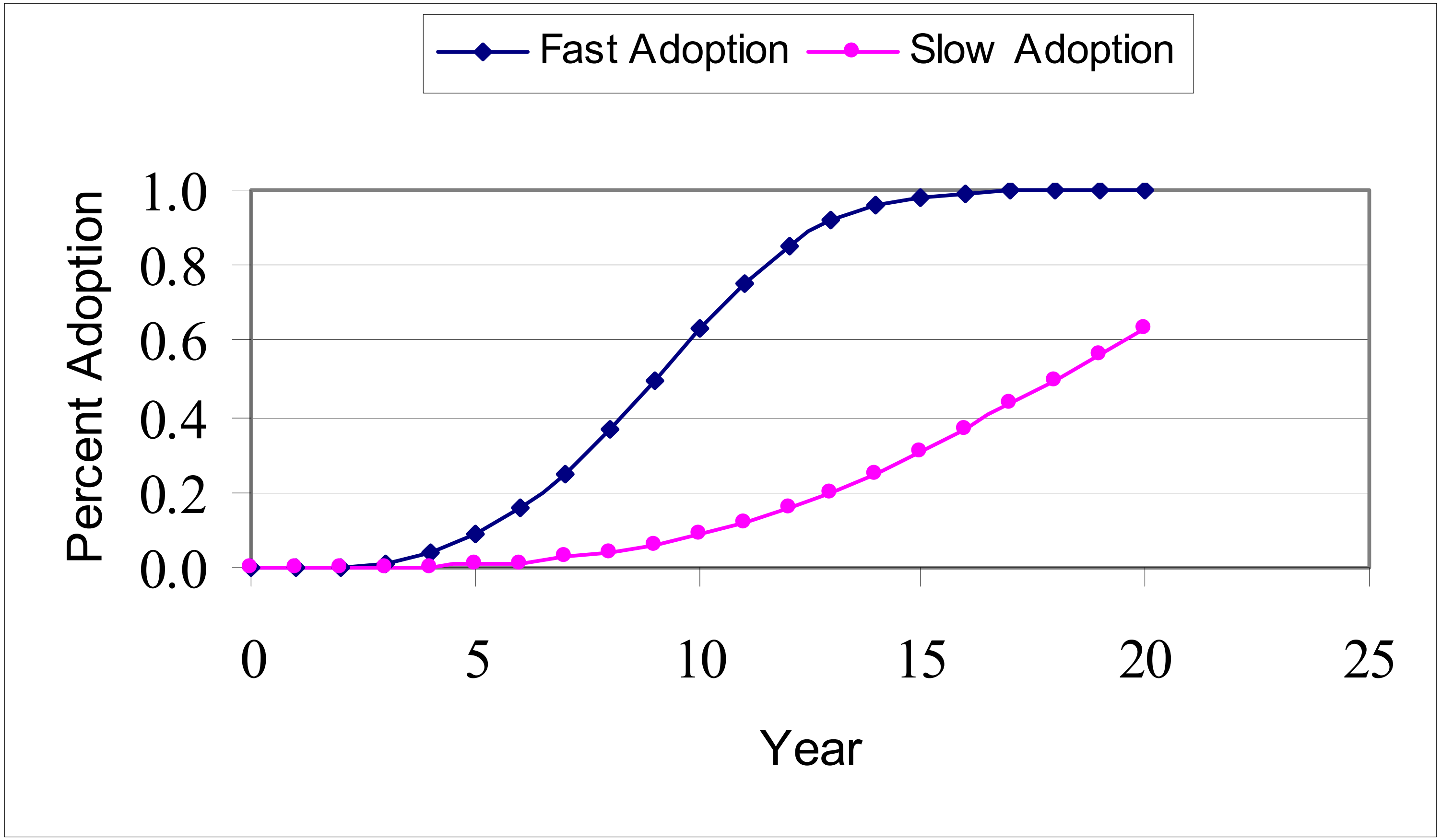
Model Framework



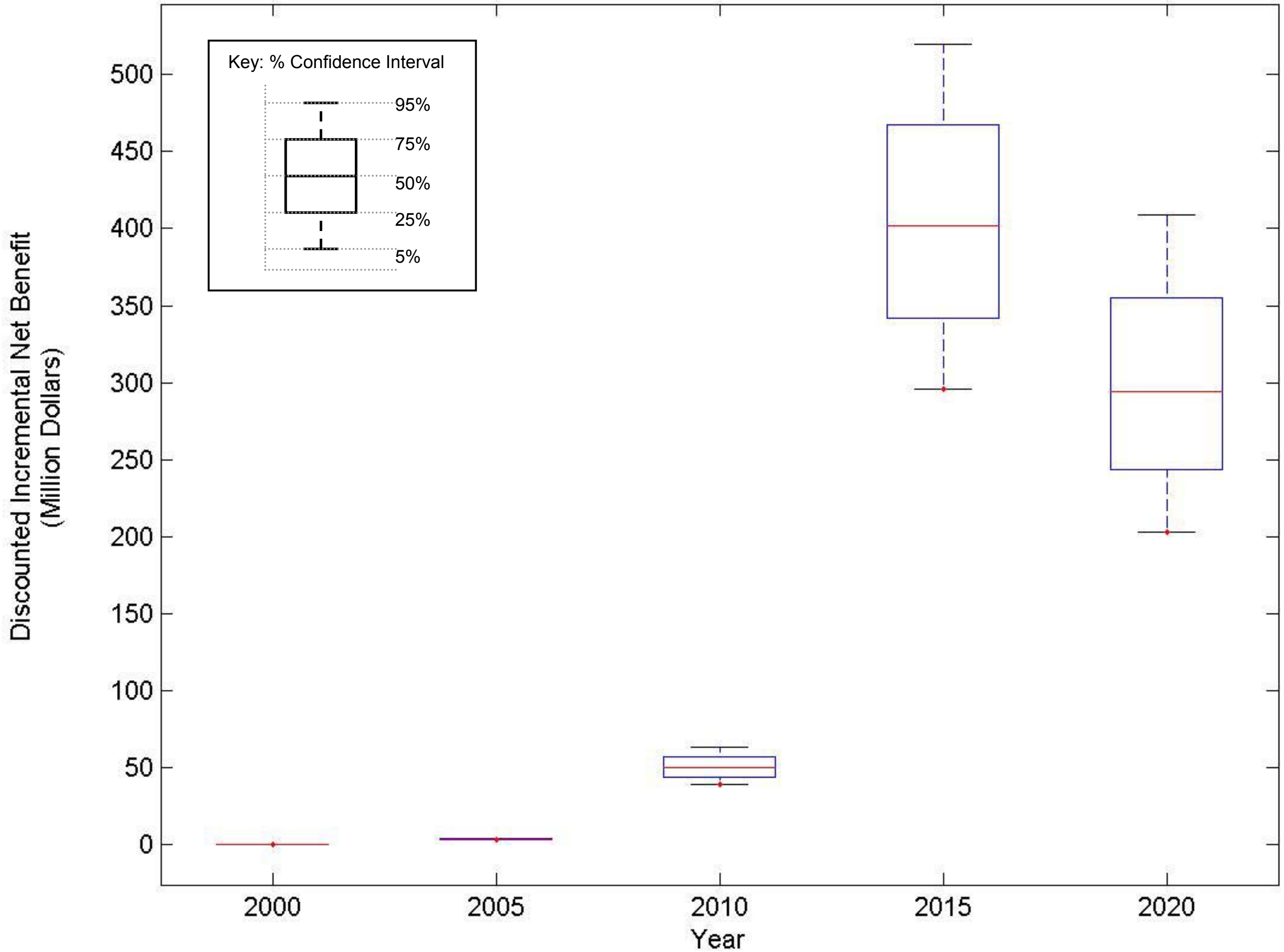
- Triangular and normal distributions combined with Monte Carlo draws characterize uncertainty.

Weibull Adoption Rate Curves

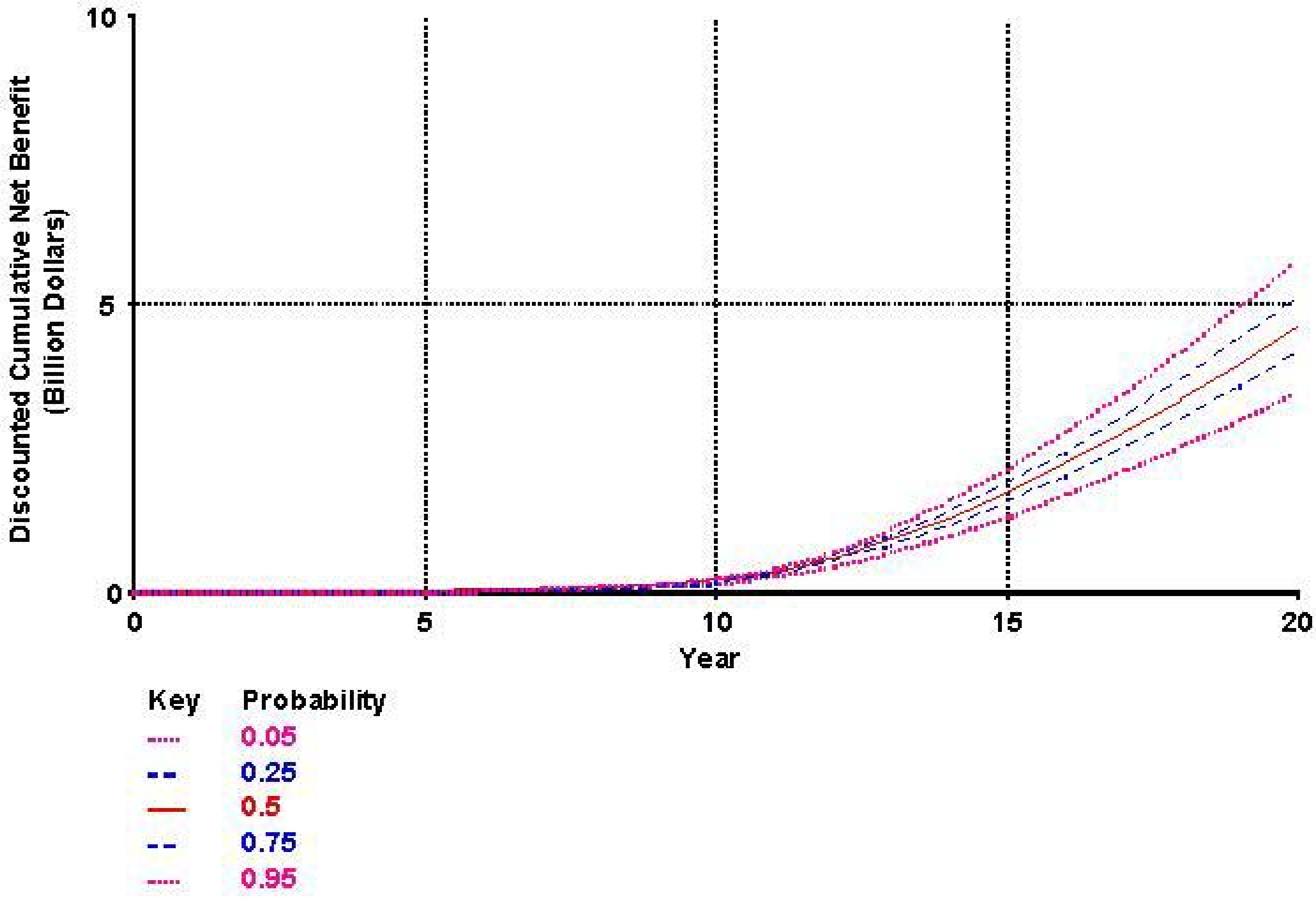
$$F(t) = 1 - \exp(-\lambda t^{\gamma})$$



Discounted incremental net benefits from 2000 to 2020 for Wind 6 from scenario 1 for CNV



The present value of benefits from 2000 to 2020 for Wind Class 6 from scenario 1 for CNV



SCENARIO 1:

Weibull: .1, 3.5
Externalities: Carbon Water
Base: EIA CCGT Growth
Discounted Present Value, 2000-2020, $ 1999 billions

Defending Technology / Innovating Technology	Conventional CCGT	Advanced CCGT
	(5%, Median, 95%)	**(5%, Median, 95%)**
	CNV	
Photovoltaics	(-13.6, -10.8, -8.04)	(-13.7, -10.9, -8.08)
Solar Thermal	(-7.02, -5.38, -3.86)	(-7.17, -5.57, -3.96)
Geothermal	(2.62, 3.47, 4.45)	(2.51, 3.31, 4.26)
Wind Class 4	(2.10, 2.90, 3.77)	(2.00, 2.73, 3.61)
Wind Class 6	(3.50, 4.60 ,5.80)	(3.35, 4.44, 5.59)
Biomass	(-5.37, -3.99, -2.74)	(-5.46, -4.17, -2.88)
	MAPP	
Photovoltaics	(-6.40, -4.62, -2.92)	(-6.51, -4.70, -2.97)
Solar Thermal	N/A	N/A
Geothermal	N/A	N/A
Wind Class 4	(0.79, 1.18, 1.65)	(0.74, 1.09, 1.56)
Wind Class 6	(1.14, 1.75, 2.41)	(1.13, 1.67, 2.31)
Biomass	(-1.61, -1.10, -0.64)	(-1.75, -1.17, -0.69)

Largest Surplus Gains Under An Exogenously Specified "Portfolio"

Discounted Present Value 2000-2020, $ 1999 Billions

Base: EIA CCGT Growth

	CNV *(5%, Median,.95%)*	**MAPP** *(5%, Median, 95%)*	***Assumptions:***
EQWTRP			**Weibull: .05, 3.5** **External Effects: Carbon, Water**
C-CCGT	(-1.54, -1.11, -0.72)	(-1.07, -0.72, -0.42)	
A-CCGT	(-1.63, -1.20, -0.77)	(-1.13, -0.79, -0.78)	
VARWTRP			**Weibull: .1, 3.5** **External Effects: Carbon, Water**
C-CCGT	(0.41, 0.84, 1.28)	(0.59, 0.92, 1.25)	
A-CCGT	(0.22, 0.68, 1.11)	(0.56, 0.83, 1.17)	

Illustrations of Expected Results

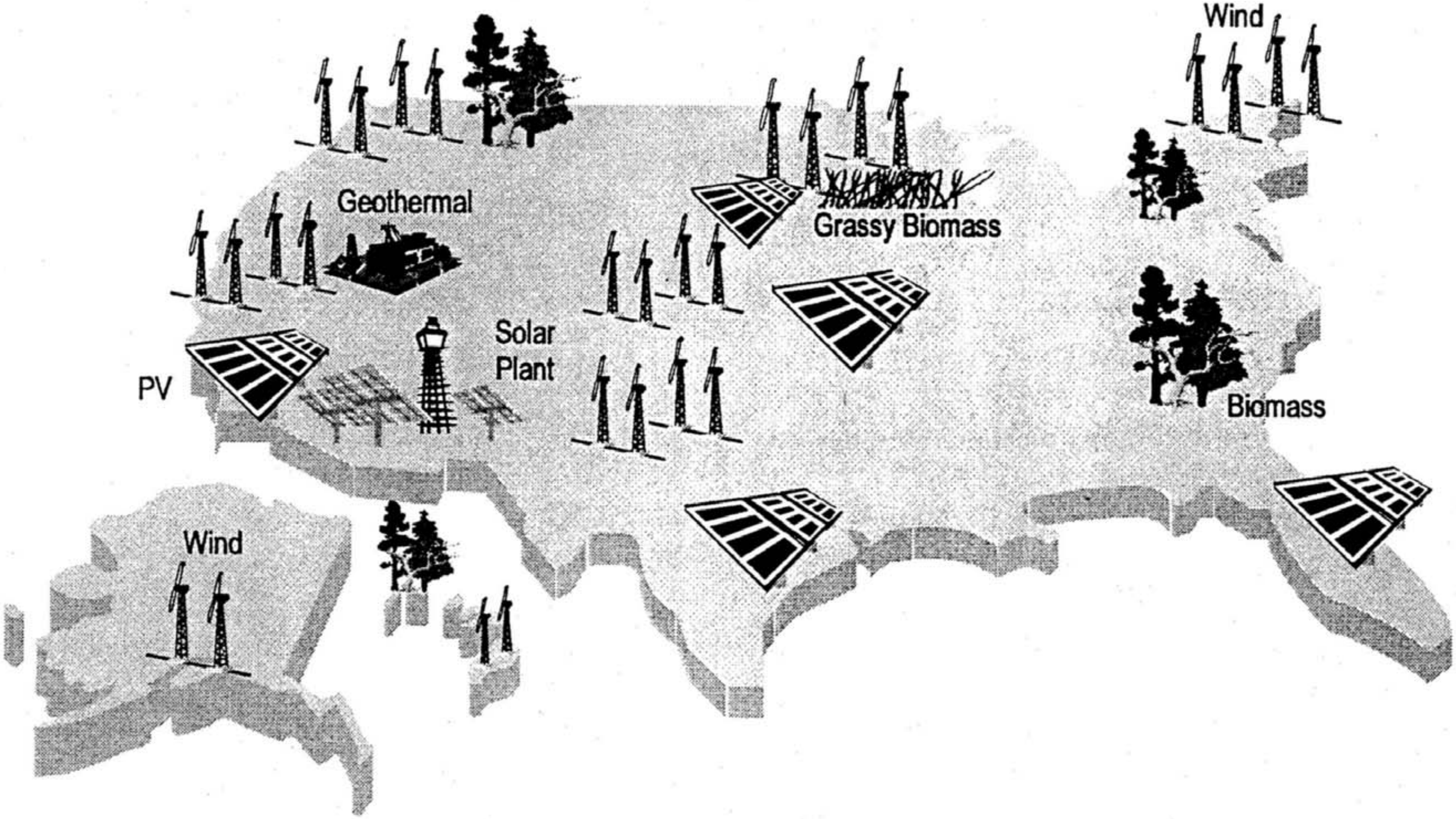
- Externalities

  -- What are the effects of carbon and thermal externalities on the relative surplus associated with renewable technologies?

  -- What are the effects of including valuation of energy security/reliability (Value of Lost Load, VoLL) on the surplus?

- Innovation

  -- What effect does innovation among terr'l technologies have on the relative contribution of SSP?



Diversity of renewable energy resources in the United States.

Other expected results, continued

- Uncertainty
  -- Uncertainty can lead to values +/- *x* % of median at the 5% and 95% confidence intervals
- Portfolio
  -- What differences do equal and variable portfolio "weights" have on benefit measures?
- Geography
  -- What role do natural endowments of terr'l renewable resources play in relative benefits?

Other expected results, cont’d

- Limits

  -- Data gaps (external effects) and assumptions (“GenCo”; deregulation; state/local/international policies)

  -- Gross not net of public and private investment or other expenditures to attain cost goals, adoption rates

Expected contribution

-- Offers conceptually grounded measurement approach; alternative to data-intensive econometric models; appeal of "cost index" analogy with Consumer Price Index; tool for program managers

-- Allows for externalities, uncertainty, policy simulation

-- Could extend to include "green preferences" (data? Are they verified?); state, local, and other countries' energy policies

-- Could extend to NRC-defined benefits including commercialization, knowledge, option values